

3-17-2010

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Implementation of Building Information Modeling in Architectural Firms in India

in partial fulfillment of the requirements for the
Degree of Master of Science in Technology

A Directed Project Report

By

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Running head: BIM IMPLEMENTATION STRATEGY

Implementation of Building Information Modeling in Architectural Firms in India

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Abstract

Building Information Modeling (BIM) is an integrated process of generating and managing a building by exploring a digital model before the actual project is constructed and later during its construction, facility operation and maintenance. BIM has been adopted by construction contractors and architects in United States (US) and United Kingdom (UK) to improve the planning and management of construction projects. On the contrary, Indian contractors seem to have made a head-start by using BIM in their projects, but the architects in the nation have still not embraced this new thinking and technology as a part of their way of working. Since BIM is not just software but a process, the Indian architectural industry needs to analyze if there is a need to start over with a completely new platform or the same goals can be achieved through a predictable and evolutionary course. This proposal will survey the difficulties faced in implementing BIM in architectural firms in India and, thus, find obstacles in doing the same. By surveying and collecting data about problems faced by these architectural firms, it will be analyzed how to avoid those situations from rising and, thus, introducing BIM capabilities in such firms in the most effective way. Hence, a roadmap for the transitioning steps needs to be formed, defining the expectations such firms should have from this metamorphosis. Since implementing BIM is a business decision, all this calls for the development of a BIM implementation strategy.

Implementation of Building Information Modeling in Architectural Firms in India

Building Information Modeling (BIM) simulates the construction project by creating an accurate virtual model of the building with all its properties. It is the latest generation of object-oriented computer-aided design systems (OOCAD) where intelligent building-objects are combined to form a virtual building. This building information model encompasses the building geometry, spatial relationships, geographic information, and quantities and properties of building components. For almost half a century, the industry used flat 2-dimensional (2D) drawings and later developed 3D parametric technology. The scope of BIM extends beyond 3D, to 4D where the aspect of time is added to form schedules and to 5D where the cost component helps create estimates. Even the 6D aspect with project controls and life-cycle management is being developed, but nothing substantial with a good BIM workflow has been established yet. For these added-values to the project, all the user needs to do is to input the data for families, components, etc., hence, building the model using intelligent materials.

BIM is one of the most promising developments in the recent years in the architecture, engineering, construction, and facility management (AECFM) industry. It has been heard of and researched upon a lot in the past decade. The integrated database allows everyone involved in the building lifecycle (that includes architects, engineers, contractors, developers, and building owners) to collocate together, allowing them to view the model in different ways, and impeccably share information. Orthographic views, quantity surveying, various performance and design analyses, fabrication inputs and rationalization, supply chain integration are just few of the deliverable products one can expect from this powerful tool which completely transforms the business.

Most BIM users today utilize it for visualization in design and documentation of the design. Data-driven analysis as the second phase is being experimented with and is yet not smoothly integrated. The last phase includes simulations where BIM imitates the characteristics of the physical system i.e. the construction project, for optimization, engineering, testing and gaining insight into the functioning.

Hence, BIM not only helps in better visualization, but is also a catalyst of a new and better process in the design and construction industry, which attempts to improvise the functioning within the project team. The transformation in the workflow of an AEC team brought about by BIM needs to be actively monitored rather than handled impromptu. BIM implementation in an architectural firm is comparable to a new technology's pursuit in any office, which requires an implementation strategy. But these process-improvement efforts should start with a conscious decision to develop optimal and not just favorable work processes. The consideration of technology should not be deferred till the end, until after the process is designed, looking at it just as a support. This process defers consideration and analyses of various processes related to the technology, thus, leading to mere automation of the old way of working. Hence, the technology should be tapped to do things not done presently.

CAD files constitute of raw data, where the facts need to be inferred by the user for understanding the relevance and meaning. This is where BIM is a step ahead of CAD. It provides all information about the elements as they are simulations of actual building components because of element's relevance to other elements and meaning and function being embedded within. This inclusion radically improves the collaboration in the design and construction team by a widely-shared knowledge and information base. Due to

sudden increase in the type and number of specialists involved with a building project today, the feedback from these to the designer has greatly suffered. The coordination occurring only at discrete points, with varying frequencies and discontinuities, causes lots of errors and rework that beleaguer the whole process finally leading to fragmentation and related overhead costs. BIM tools can feed these data into the integrated model in parallel to the design process drastically increasing the speed, accuracy and quality of the output. These add-ons available simultaneously can serve as an aid of the design, rather than surface later to repair it, thus helping cut down on time and money wasted in the latter mode. The BIM tools serve as omnipresent consultants and help designers make decisions faster, based on quicker comparisons and analyses provided within hours, instead of days taken for feedback by traditional consultants.

BIM takes an understanding of both the industry and the technology to leverage its full potential. To ensure integrated delivery, the BIM generated simulation must be digital, spatial, measurable, comprehensive, accessible and durable. Presently, no software uses all these characteristics and it may take several years to develop one. But the software applications being used for BIM all over the world (for instance: Autodesk Revit, Autodesk Navisworks, Graphisoft ArchiCAD) currently use a combination of the above mentioned characteristics. Though BIM is currently being employed by professionals on all building types from the simplest warehouse to many of the most complex new buildings, BIM design method is currently young in its development.

Summary Problem Statement

Designers all over the world are implementing BIM as a new technology in their firms, while their Indian counterparts are not tapping the true potential of BIM tools and using them for visualizations and walkthroughs (Autodesk, 2005). This neither implies that the Indian designers are ignorant of BIM and its ability, nor does it exhibit a dearth of skilled BIM users in the Indian AEC industry. In fact, there is lot of outsourcing of full range of BIM services by development centers in India, delivering built environments for projects designed in US, UK and European countries, thus, helping them steer clear of huge delays, major cost overruns, clashes detected on site, etc. AEC firms in US, UK and European countries are utilizing the Indian talent. These firms are enjoying the benefits of not only the cost effective production but the expertise that India has developed in over 2 decades of experience. (PRLog, 2007)

Indian architects are suddenly designing complex and multifarious projects. There is a need for direction of development, integration of information technology and business processes for simulation, coordination, communication and knowledge sharing to support design and construction. Currently, there is no clear consistency about the process of implementation or usage of BIM anywhere in the world. Even the Associated General Contractors (AGC) of America realizes that there is an absence of a single document that instructs application of BIM in firms. Several software firms are trying to cash-in on the new inquisitiveness for BIM and have developed programs to address certain aspects of BIM technology, but none of them treat it as a process of transformation. This fact brings forward the need to standardize and create guidelines for the implementation of BIM process in the global context.

Significance

Architecture is a profitable business in India, which has a diverse client base (Autodesk, 2005). Staff is well trained and all systems and processes are consistent with global best practices. In the past decade, India's hunger for IT parks, mega-malls, and huge residential communities became insatiable and, hence, architects designed supsize projects dreamed up by Indian developers. India is a developing country and there is still a shortage of housing and office space. There is also a shortage of just about every kind of infrastructure for the huge population and growth in every sector (Autodesk, 2005). And thus, there is lot of planning and construction in full swing.

India has a large and relatively inexpensive labor pool which decreases the value of productivity improvements that BIM offers. Lower cost of workers has discouraged efforts to replace field labor with automated solutions. But not to forget, BIM offers time savings and competitive advantage. It allows for quick turnarounds in the intense time pressure and competitive environment of India.

The architectural firms should aim to engage and materialize the paradigm shift in this increasingly connected world and move with the progressing architectural technology and engineering. There is a need to design in a non-deterministic and democratic manner, viewing all buildings as products of the constantly evolving process, rather than have a closed opinion about the design from the beginning. BIM helps the design evolve on various fronts. This research oriented approach to building engineering, materials and construction technology allows continuous experimentation with new emergent architectures in search for tectonic perfection.

Statement of Purpose

BIM models usage fused with analytical and simulation tools allow us to efficiently prototype a building, check its performance and activities related to its construction before breaking the ground. Such prototyping holds a lot of value. BIM implores designers to avoid fudging practices, hence, improving quality and productivity and bringing about best practices. However, using BIM data only to produce shop drawings is not the correct method. To harvest true value, BIM needs to be used to develop a reliable digital model for accurate quantity take-offs, schedules and estimates to radically reduce time and effort spent on the same. The purpose of this directed project was to appraise the obstacles faced by Indian architects in adopting BIM, while keeping in mind the special characteristics of Indian AEC industry, finally forming a BIM implementation strategy.

Definitions of Terms

Building Information Modeling (BIM): The process and technology of digitally constructing an accurate virtual model of a building is known as Building Information Modeling. When completed, the computer-generated model contains precise geometry, spatial relationships, geographic information, quantities and properties of building component needed to support the construction, fabrication, and procurement activities needed to realize the building.

Object-oriented Computer Aided Design (OOCAD): A new idea for modeling physical objects such as building components, where elements of a building are represented as objects, containing the physical geometry as well as many other kinds of attributes is called Object-oriented Computer Aided Design.

Three-Dimension CAD (3D): The drawings and models developed and represented in geometric model of physical world in terms of length, width and height are referred to as three-dimensional. These can be represented as wireframe or solid models and use virtual reality.

Four-Dimension CAD (4D): When the aspect of time is added to three-dimensional project components to generate construction schedules automatically integrated in the 3D model, we achieve a four-dimensional representation, which dynamically manages the resources over time.

Fifth-Dimension CAD (5D): When the fifth dimension of cost is added to a four-dimensional representation to generate estimates, we form a fifth-dimensional model, which helps in planning costs and resources.

AECFM Industry: The architectural services industry dealing with the architecture, engineering, construction and facilities management.

Assumptions

This proposal assumed that BIM will be used from conceptual design stage till the construction phase of the project, based on a single data source. An integral part of this project was the expectation that designers will be using BIM to develop a physical as well as analytical model of the building project, facilitating both upstream and downstream integrity and satisfying all participants of the team. Further, the technicians were assumed to be BIM-proficient to tap the advantages of this new technology.

Delimitations

The delimitations of this project were to conduct the study on 25 architectural firms spread over Indian subcontinent. All firms being studied were purely architectural

firms, not doing any contractual or construction work. Also, all architectural firms studied were active users of CAD system and well-versed with the same. Firms of all sizes – small, medium and large were studied for an overall opinion of the industry, not specific to a specific segment. Advantages of systems or methods substitute for BIM and their application in similar firms were not looked into or compared.

Limitations

Time constraint did not allow a follow-up after the initial treatment. The firms studied consisted of designers with good computer skills and good experience in the construction industry, but had not used BIM before, thus any learning or improvement as a result of using new technology in some cases was not forecast.

Literature Review

Introduction

The review of literature revealed many studies relating application of BIM in AECFM industry. This integrated process allows the team to explore a project digitally before it's built and, thus, proves its caliber as an accelerated production mechanism. This culture permeates a new way of thinking about building design by acting as a catalyst in the industry and reduces its fragmentation. To ensure integrated delivery, this simulation must be digital, spatial, measurable, comprehensive, accessible and durable. Presently, no software uses all these characteristics and it may take several years to develop one (Eastman, Teicholz, Sacks & Liston, 2008). The following paragraphs will explain the history, growth, and current trends in BIM.

Background

In earlier times, the architect was the mastermind behind the project. These projects were small in size and simple to execute (Kymmell, 2008). Hence, the architect himself communicated his ideas about planning, design and construction on-site. His was the only mind which could solve problems, address issues, and had all the information.

Later, the projects grew larger and more complex. It was then that the notions of the architect were expressed to the builders and owners in the forms of models and drawings. Gradually, there was removal of master builder from site and communication of design gained importance. Specialty fields developed and the scope of work in projects increased. Nature of the problems faced during projects hasn't changed, but their complexity has. The project still needs to be coordinated well and it is a difficult role to be played by one person due to various approaches to project delivery methods. This is when BIM is needed to manage the essential building design and project data in digital format throughout the building's life-cycle i.e. in design, construction and management phases.

Building Information Modeling

Earlier, CAD systems were used to produce drawings and three-dimensional images. Now the focus has shifted to the data itself. BIM has following components: those with behavioral data, those that build (with intelligent digital representations), those with consistent and non-redundant data, and those with coordinated data. All of these enable the architects to catch and avoid the costly mistakes and in a way, virtually try the building before incurring the huge expense of building it in real-time (McGraw-Hill Construction, 2008)

BIM helps construct a virtual yet accurate model of the building in the digital world before raising it in the physical world. This building model supports construction, fabrication and procurement activities and, thus, can be used for feasibility studies, conceptual design, more accurate estimating, relative detailing, easier coordination, etc. by the architectural firm; and also for construction planning, logistics, operation, etc. by the other members of the team (Larson and Golden, 2008). Another use the architect can employ BIM for is to study the building's performance, such as solar studies, energy usage, green building analysis, construction costs, sequencing of construction, etc.

BIM allows easier coordination of different software and project personnel, which leads to improved productivity, communication and quality control (McGraw-Hill Construction, 2008). It transforms how buildings are built, how they look and how they function – adding intelligence to the buildings. The powerful 3D model helps visualize, present and create architectural documents. It helps save time and reduces errors as design changes are automatically coordinated throughout the entire model. Not only are the building elements represented as 3D objects, but it also accommodates associated information about each element.

The concurrent information is kept up-to-date and digitally accessible, giving clear overall vision and ability to make better decisions faster. Using BIM technology, all phases of design, scope, documentation, cost information and scheduling can be better coordinated, leading to better reliable quality and allowing for higher profitability for the project team. Changes can be made without laborious, low-value coordination and manual rechecking. Hence, the architectural industry in US ends up saving time and

money, making fewer errors, getting greater productivity, higher quality of work and repeat business opportunities (AIA Knowledge Resources Staff, 2008).

Architectural, mechanical and structural elements are most likely to be modeled in BIM. In the US, architects are the heaviest users of BIM, with 43% using it on more than 60% of their projects, and it is observed that BIM has a very positive impact on architects' businesses (McGraw-Hill Construction, 2008). In India, the client enters into agreement with an architect defining their scope of work, responsibilities, functions, fees and mode of payment. Once the architect has completed the design, he prepares working drawings, specifications and schedule of quantities sufficient to prepare estimate of cost and bid documents. He also invites, receives, analyzes tenders and advises client on appointment of contractors (Council of Architecture of India). Hence, in determining whether BIM should be used on a project, architects are considered the primary drivers of BIM use among all build team members, making them the top decision makers. As a matter of fact, BIM was initially developed with a focus on the design world.

BIM reduces risk of errors' occurrence in the design process (Rundell, 2007). Human errors are caught and corrected during the design process itself due to the extended coordination and communication across the entire project team. BIM improves design decision making, prediction of performance, cost estimation and construction planning with automatic document coordination and clearer project communication.

Quantity takeoff, scheduling and estimating are the top most popular tools used in conjunction with the integrated modeling data (Tulke, Nour and Beucke, 2008). BIM enables quantities of materials to be tracked throughout the project, hence, allowing quantity takeoffs and cost estimates to be more accurate and reliable than those prepared

using conventional methods. Less field staff can do the work of a typical larger staff if contractors employ BIM on the construction site too.

Current trends in the industry

Currently, the industry produces the paper documents (blueprints) which are not 100% accurate because all the three-dimensional ideas are transformed into flat drawings (Jaafari, 1996). There are unanticipated field costs and delays in the process, many times leading to lawsuits. All of the above causes lot of friction, financial expenses and further delays. BIM helps minimize costly and time-consuming redesigns. Today, the architects need to rethink all of the methods they have been using for hundreds of years.

The architectural firms which have already adopted BIM for their projects are currently not utilizing its full potential. For example, PMK Architects (Bangalore, India) are using Autodesk Revit Building for visualizations and walkthroughs, thus, allowing speedy approvals from the clients' and regulatory authorities' end. Another Mumbai-based firm – Ajit Bhuta & Associates uses principal architect's paintings for conceptual designs. His designs needed flexibility and versatility to generate creative designs with coordinated documentation – all made possible by use of Autodesk Revit. During a summer internship at Larsen & Toubro, the author has seen the firm use BIM technology in initial stages for making conceptual views and to experiment with various design alternatives in a short span of time. Indian architects are realizing that BIM technology helps them deliver high-quality outputs in projects.

For instance, BIM automatically places the information pertaining to every building component into the specification booklet. If that component is moved or eliminated, the software will move or eliminate the window and all associated references

throughout the drawings. Currently, if a component is removed from the drawings, the architect would need to carefully look through hundreds of sheets of drawings to find every location in which the window appeared. Now with BIM, the change made in the drawings is instantaneous and the drawings are automatically updated and accurate. BIM's ability to identify, locate and alert the architect to a conflict between building components is also very helpful.

Barriers on BIM implementation in India

Implementation of BIM in India faces the problems concerning cost of software, new hardware and training employees. Adequate training required in the firms is one of the biggest obstacles to BIM adoption, followed by senior management buy-in. Since most of the architectural firms in India still use 2D drafting software like Autodesk AutoCAD, they are not keen on investing time in training the staff or investing money in new technologies involving BIM culture that permeates a new way of thinking about building design in the industry (Bedrick, 2005). Also, very few owners are ready to pay the extra cost for digital models of their project which offer expanded services in the future (Scheer).

Most firms predicate that BIM implementation will result in productivity losses during the transition period. But these initial productivity losses are covered up by productivity gains down the line (AGC, 2006). On the contrary, the fact that BIM technology integrates seamlessly with the current ways of working should not be overlooked. The present systems need supporting technologies to aggregate information across the different applications, thus, radically transforming the design and construction processes in the industry.

Another cause of worry for the architectural firms is the question about how long will it take the designers to transition to BIM, especially because they are so comfortable with the existing tools. But these BIM solutions are created to specifically cater and function in accordance to the way of thinking of the designers and are easy to learn. Firms are also apprehensive about workflows and the rate of progress changing due to bringing in of BIM. But in practice, it disrupts only inefficient workflows, pushing them to follow better design processes with more informed decision making (Autodesk, 2007). The enhanced collaboration workflows help designers to investigate and visualize design details or intricacies of the structure without the help of draftsmen.

It is also argued that the owners and contractors reap most of the benefits from adoption of BIM. The time and efforts saved by BIM helps the designer to concentrate on high-value design and deliver best value to the owner. This is more helpful in tight schedules or staff shortage scenarios. Also, if a designer provides a superior set of construction documents with more details, it helps him get better pricing and execution during construction.

India's large and relatively inexpensive labor resource decreases the value of improvements in productivity, which can be tapped by the use of BIM (Autodesk, 2007). But BIM has the ability to reduce the project team's size. This lowers the firms' IT infrastructure costs and reduces real estate costs as the amount of office space required also reduces. Not only this, but BIM also offers benefit of time savings and competitive advantage, thus, helping overcome time pressure and global competition. In a country where there is lot of competition especially at cost-front, BIM makes sure that more of the owner's money goes into the building than the administrative, documentation and

overhead costs. This study did not investigate if the architectural firms realize this fact or not, though it has a huge impact on utilization of BIM.

Options

Before committing the funds to this new technology, a return on investment (ROI) analysis compares the gains anticipated from this investment against its cost. Autodesk did the above analysis taking cost of hardware and software, monthly labor costs, training time, productivity lost during training and productivity gain after training as the variables in ROI calculation. Though Autodesk employed an online survey and used typical numbers for the calculation to deduce an ROI of just above 60%, many architectural/design firms in the United States adopted the technology to actually measure their performance against the plan and reported gains of over 100%.

BIM use on construction projects is growing rapidly. McGraw-Hill Construction surveyed hundreds of owners, architects, civil, structural, and MEP engineers, construction managers, general contractors and trade contractors in United States, who are currently using BIM. 62% of users surveyed indicated that they will be using BIM on over 30% of their projects in 2009. The research findings also clearly indicate that BIM expertise leads to greater understanding of BIM benefits and the value of using BIM – 82% of BIM experts believe that BIM is having a very positive impact on their company's productivity and 44% of BIM experts now regularly track BIM ROI (McGraw-Hill Construction, 2008). This powerful trend points to an unstoppable wave of accelerating adoption and creative implementation that will redefine project delivery and affect every company in the construction industry.

CAD versus BIM

The currently widely used CAD technology supports drafting automation effectively but needs lot of efforts for the same. Lot of standards need to be enforced for high quality of information and the same is dependent upon reliability of users entering data (Azhar, Nadeem, Mok and Leung, 2008). The object CAD technology simulated building components focusing on 3D geometry, object properties and quantities. It is very effective in coordination, carried rich data and can be extended into BIM. Also, its implementation is easy and yields benefits immediately. Parametric building modeling technology corresponds with decision support systems which combine data model and behavioral model giving meaning to the data through relationships where all information is interconnected. This method is uniquely suited to support highest level of effectiveness with least efforts. This technology needs to be adopted completely as it cannot work effectively in the current non-BIM environment and results in self-coordinating model.

Some software applications which help user do three-dimensional modeling without any object attributes are usually used for visualizations. However, BIM technology comprises of modeling with behavioral support and consists of lot more than just two-dimensional CAD references. BIM is a model-based technology linked with a database of component information and it reflects small changes made in one view to another. Work duplication is minimized and many lower-level tasks are automated, allowing designers to concentrate on the essential. BIM finally brings to fruition what the building industry expected of CAD in the early 1980s: it helps the entire building process value chain achieve a faster, higher quality and richer design process.

The current standard drawings usually do not provide complete information needed by the contractor, leading to innumerable Request for Information (RFIs) (Bernstein and Pittman, 2004). But with BIM, the contractors have unlimited sectional views or details of all areas of the building, which were previously unavailable and had to be requested for. This special access to the building's virtual model gives a higher level of clarity of thoughts and ideas from the designer's end.

Conclusion

BIM offers an integrated design and analysis environment. Along with the creation of physical design model, an analysis model is automatically created and synchronized with design model and documentation. This increases productivity by avoiding duplication of effort and manual coordination. For improving the quality of design and drawing deliverables, the accuracy of the model needs to be worked upon. Productivity improves with BIM, allowing firms to accomplish much more work with the same resources.

There is a need for timely exchange of building related information, which requires considerable amount of time and expenditure. What this technology offers to us, what it enhances, what it diminishes is all dependent on how well and at what stage the team starts collaborating on the digital model. Value engineering must be undertaken to address the inconsistencies and all related analysis should be done in initial stages, not left for the last when it gets too late to make the changes.

BIM is a technology that empowers the user, while it is also a business and organizational issue for the firm it is adopted in. As BIM is based on the principles of a modern integrated practice, all the members of the team can feel the impacts of its

implementation and usage. It helps bring together the design and technical needs of a building at a parallel platform, giving a critical and holistic approach. BIM proves its caliber as an accelerated production mechanism.

BIM is a revolution which cannot be incorporated without understanding its cultural implications. It represents a paradigm change which will have far-reaching benefits. It is not just software or an object. It is a process – a process that will finally bring about crucial changes in the entire industry. It is a process that leads to better quality of the project, one that is completed with greater speed and more accuracy. Ultimately this process will lead us to build better buildings. The design, construction and usage of these new buildings will consume lesser energy, labor and resources.

BIM is still in its formative years and what is seen right now is only the tip of the iceberg. The community is still on the outermost core and has explored just the primitive things BIM is capable of. It makes the amalgamation of different team members seamless. Real-life elaborate studies can be done for the building, against earthquakes, wind, temperature, sun, rain, construction sequencing and other effects. These help analyze how certain building forms will perform under different conditions.

Methods

An establishment of goals to be achieved was done for this study to implement BIM in the architectural firms in India. Data about requirements from a BIM system in these firms and hurdles faced in the same was collected. This method surveyed and outlined the implementation strategy to support this transmutation to the new technology.

Methodology Rationale

It was kept in mind that BIM is a business decision but its implementation is a management decision. This study expected to form a business strategy to be employed by architectural firms to successfully implement BIM, which will lead to radically new capabilities within the design firm. The deliverables help identify the customer and the supplier both for the establishment of relations and develop the flow of information. Diligent planning of the deliverables formulates processes required in the path of BIM usage. The new strategy had to take care of the management of these processes which finally generate the required information. The knowledge of the resources enabled depiction of the flow of work. The communication protocol has been developed to support the goals.

Theoretical Framework

The project team responsible for information processing is the first resource which needs to be considered during this implementation. The selection of team, their role, skills, strengths, and weaknesses are important while assessing the available human resources. Outsourcing of the model does not benefit the firm as the understanding is gained only by the modeler and not to the same extent by the user. The team structure needs to be established for clearer work definitions and, thus, resulting in a communications protocol.

New roles emerge – one of BIM manager, another of BIM operator and last of a BIM facilitator – each requiring different skills and responsibilities. A BIM manager needs to have good understanding of the concepts and applications of BIM as well as project management. A BIM operator needs to perform BIM-related tasks, hence, more

tool-related skills than managerial skills. A BIM facilitator does not have a parallel in the current construction industry as he will guide the rest about navigation in the BIM world.

After team assembly, BIM related specific processes need to be assessed before implementing the same. Hence, the methods need to be chosen, though they may differ from one firm to another based on actual skills and resources available. These processes are either information-related or tool-related, concerning information-management and tool management respectively. Also a step-by-step approach is to be followed for incremental training and adoption of advanced services without undue risks. In addition to the design services these firms offer their clients, they can use BIM to develop new contractual opportunities with new scope and limits; hence, enhance design value and generate extra revenue.

Procedure Design and Participants

The qualitative research helped gain in-depth knowledge about the processes related to BIM and the processes in the cycle. For various data collection, different architectural firms from all backgrounds were identified and invited. Various firms where BIM was adopted for a project design were surveyed and its effects were tabulated. The hurdles faced in the path of adoption of BIM by various architectural firms were collected and then problem-solving approach was used to develop a strategy to avoid the same in the future. This helped in formation of the transitioning roadmap.

Survey

This study anonymously surveyed the architectural firms which have used BIM at least once about the impediments they initially faced in the path of BIM implementation. The survey also tried to find out the most preferred BIM

software in the Indian AEC Industry. Various architectural firms in India not using BIM currently were also surveyed to know their inhibitions in the process and their myths regarding the same.

Participants

Principal architects and CAD technicians in architectural firms from all over the world were interviewed via online survey, for this study. All the data was collected and analyzed only by the author.

Data Collection Framework

Though data was collected at all levels, it was not restricted or focused on the technicians or CAD managers, but more on the visionary of the firm as he understands the business of architecture. It is his passion and expertise that enables the whole team to function in a design process. In architectural firms, such a pragmatist is called the “principal architect”.

Data Collection Procedure

A combination of postal questionnaires and personal interviews were used for this study. Government standards about BIM implementation/adoption were studied to identify existing 3D BIM standards or best practices throughout the industry. Key technical advancements to be made in projects using BIM were also considered.

Data Analysis

Opinions were collected and analyzed to develop implementation plan to inform and revolutionize the cost & schedule industry to promote this technology. This will also help the firm develop its BIM manual and guidelines, to move to

BIM in a logical and scalable manner. These are then first applied to a typical pilot project to do benchmarks and comparisons. This is when not just the technology in the firm changes, but also the vocabulary and the perception of the designers.

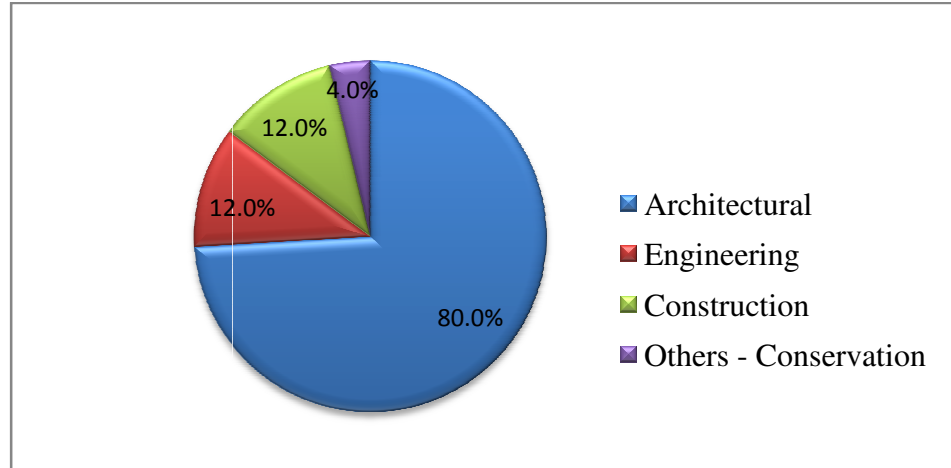
Threats to Validity

The threats to the internal validity of this experiment were reduced by the method of data collection and the one to one interaction in surveys. The skills and knowledge of staff of different firms posed a threat to the validity of the results. The transitioning during the first project team is usually different than the transitioning for rest of the office. Hence, it had the tendency to curve the results.

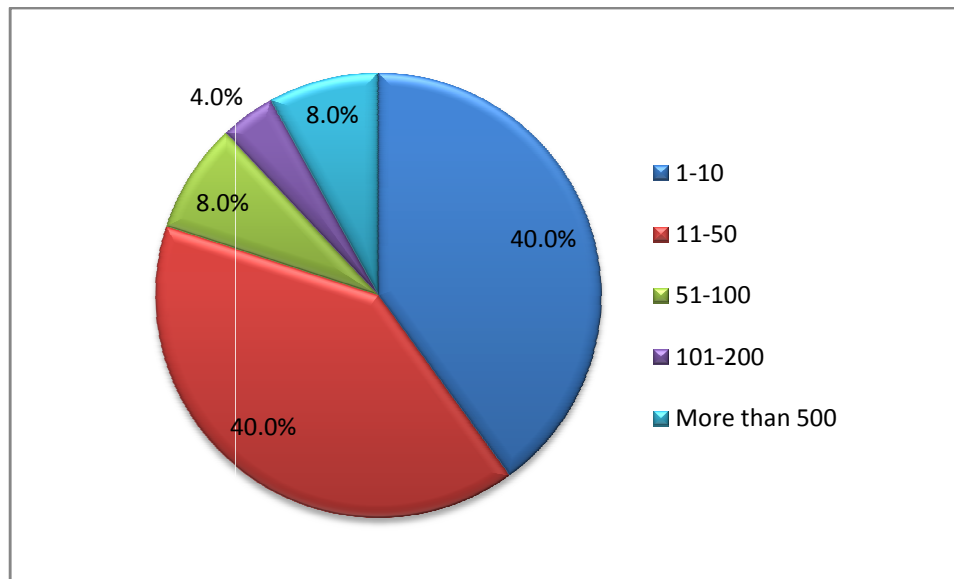
Findings

During the course of this research, several findings were determined for BIM implementation in architectural firms in India at present. The survey was sent out to 45 Indian architectural firms, out of which 38 firms responded to the survey. Since the survey contained a certain set of questions to be answered only by BIM users, the survey was 100% completed by 25 firms. The complete survey sent out to the architectural firms is attached as Appendix A and the responses for the same are as below:

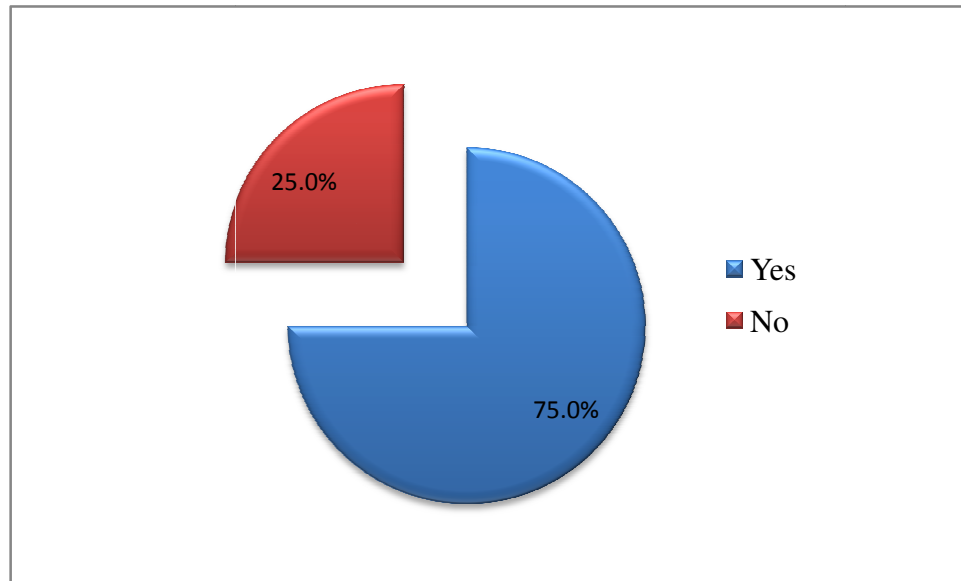
1. Please select the nature of your firm. Select all that apply: (25 respondents)



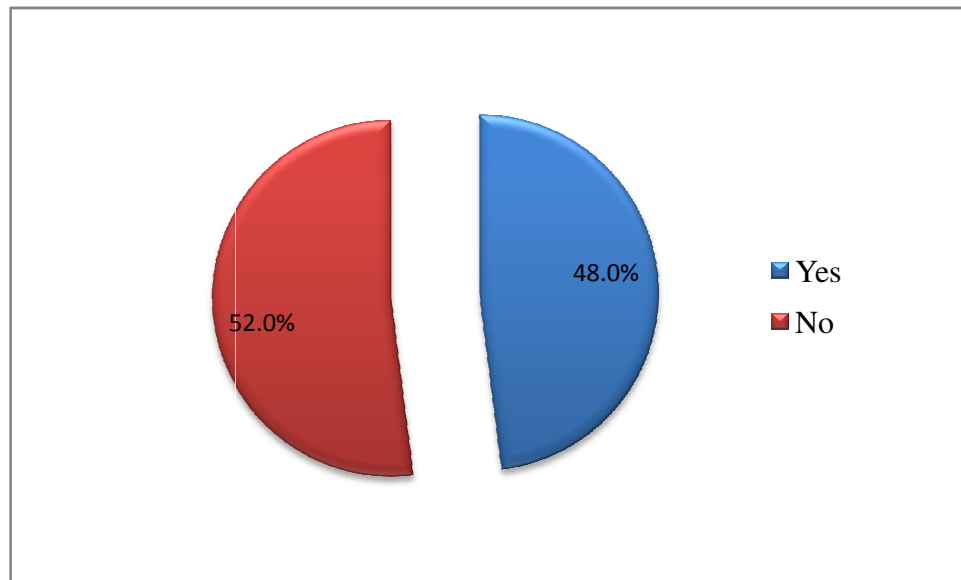
2. How many people work in your firm? (25 respondents)



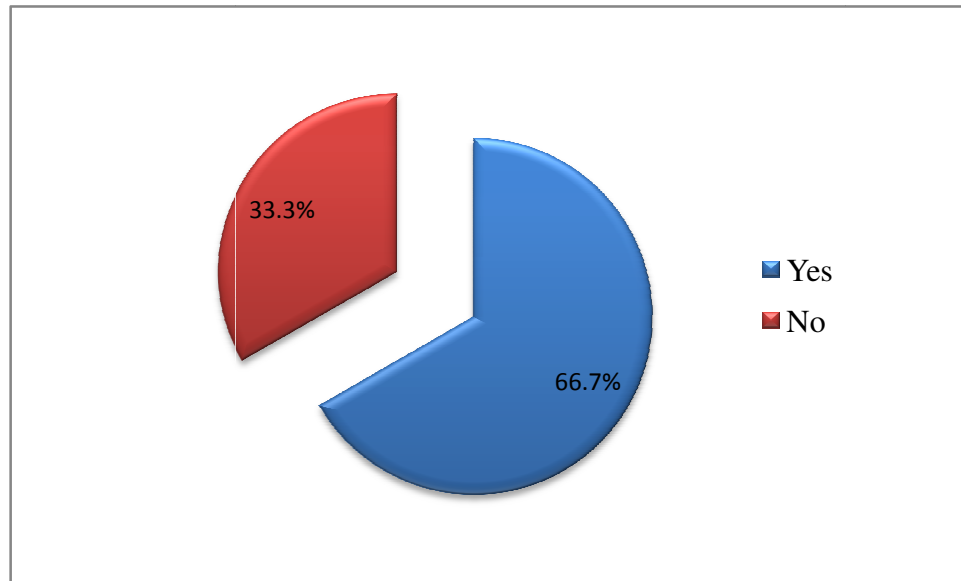
3. Have you heard of Building Information Modeling (BIM) solutions and applications? (24 respondents)



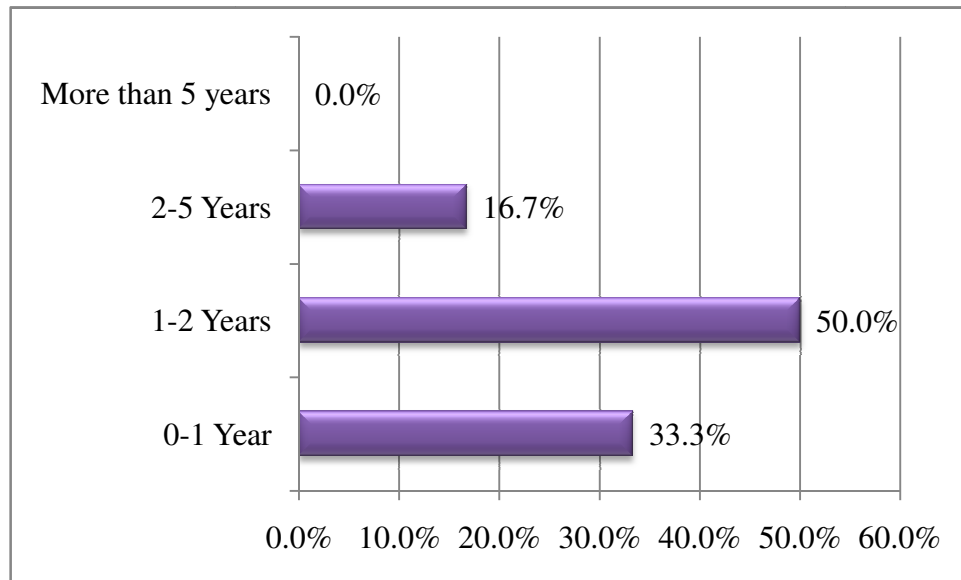
4. Have you ever used BIM solutions and applications? (25 respondents)



5. If the answer to Question#4 is NO, please skip questions 5-18. If YES, are you still using BIM solutions and applications? (12 respondents)

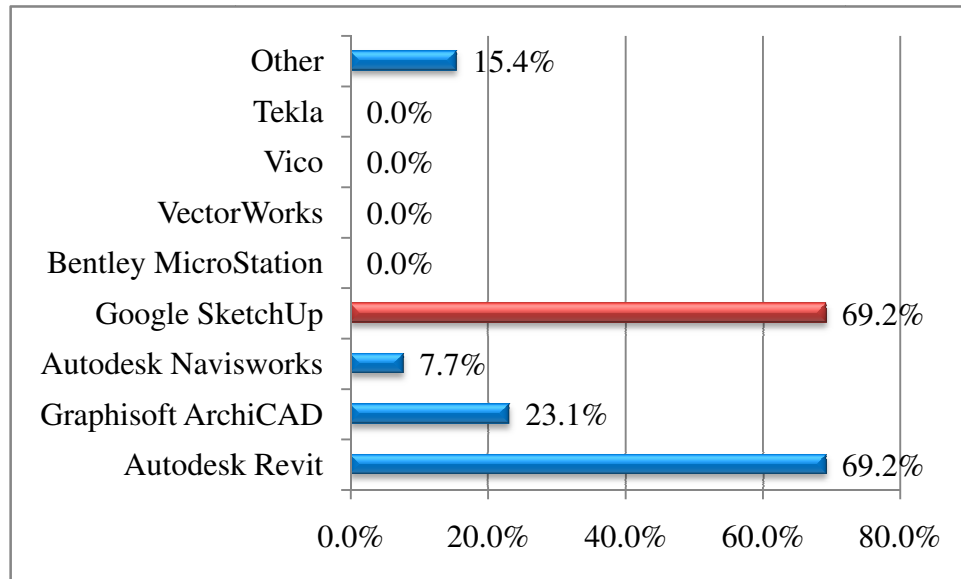


6. For approximately how many years have you used BIM solutions and applications? (12 respondents)



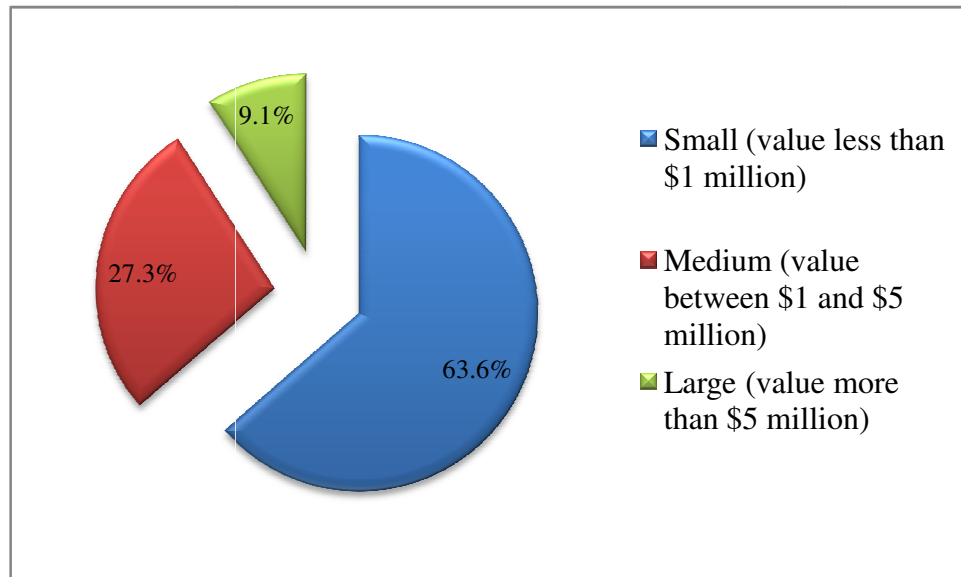
7. Which software vendor(s) do you use/have used for BIM? Select all that apply.

(13 respondents)

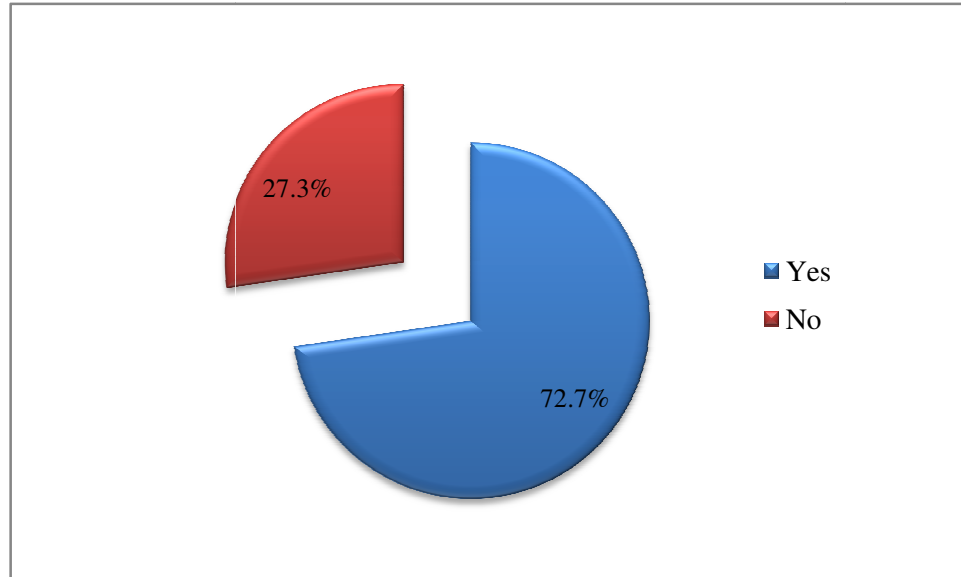


The other software packages are IES-VE, Ecotect, Catia, and Digital Projects.

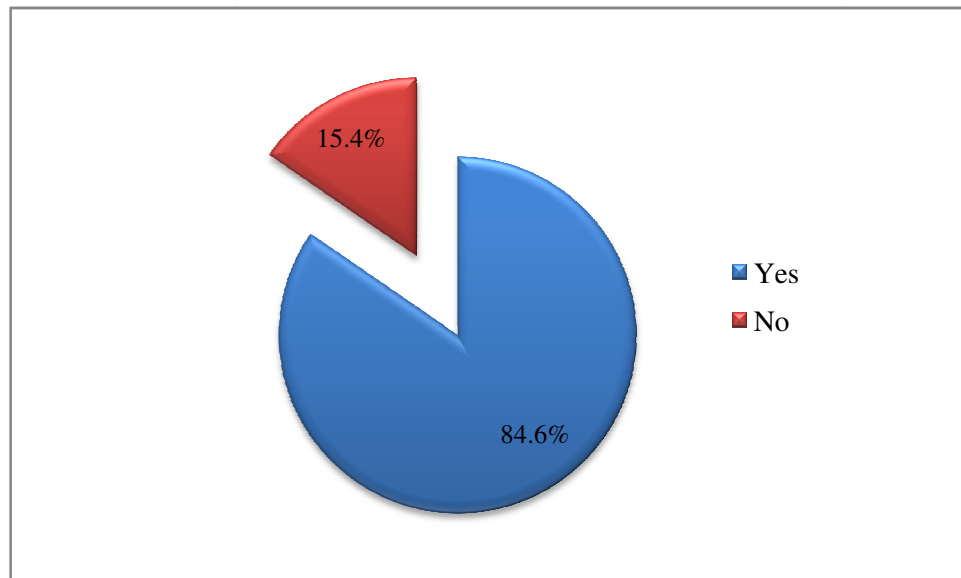
8. A pilot project refers to an initial roll out of a system. What was the size of your pilot BIM project? Note: \$ refers to US Dollars. (11 respondents)



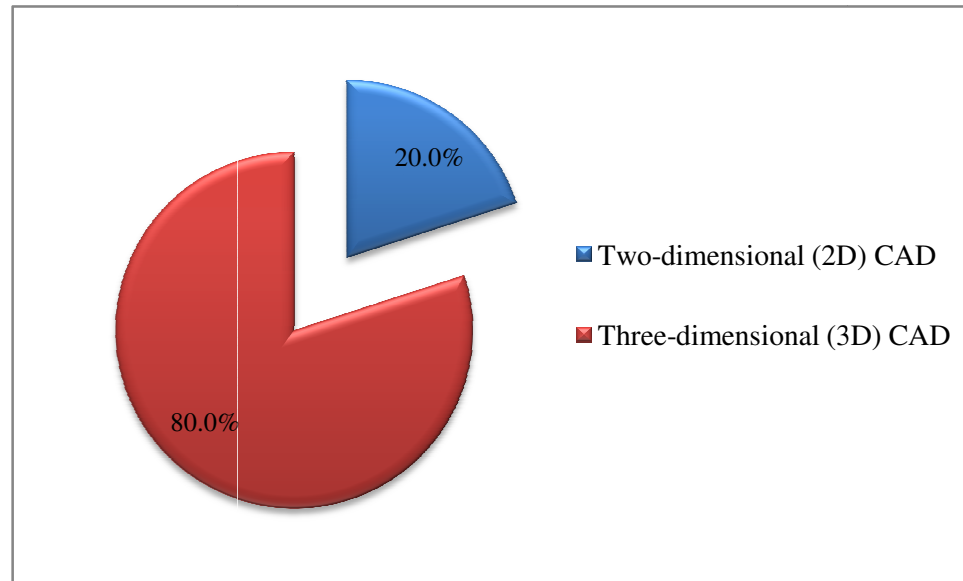
9. Was the pilot BIM project first-of-its-kind for your firm? (11 respondents)



10. Do/did you use BIM solution in conjunction with Computer Aided Design (CAD)? (13 respondents)



11. Which of the following CAD applications are you using currently? (25 respondents)



12. Please respond to the following statements: (24 respondents)

	Strongly Agree	Agree	Neither Agree Nor Disagree	Disagree	Strongly Disagree
Clients are willing to pay extra for BIM services	0.0%	45.8%	41.7%	12.5%	0.0%
Our clients possess adequate knowledge of BIM and its various deliverables	0.0%	16.7%	8.3%	66.7%	8.3%
BIM is useful for different design and documentation tasks	37.5%	62.5%	0.0%	0.0%	0.0%
BIM usage increases the level of service, quality and performance of the architectural firm	54.2%	37.5%	8.3%	0.0%	0.0%
I am satisfied with BIM software and capabilities	20.8%	41.7%	33.3%	4.2%	0.0%
It is easy to learn and use BIM software	8.3%	33.3%	29.2%	25.0%	4.2%
BIM is faster than CAD	4.2%	41.7%	45.8%	8.3%	0.0%
BIM is more efficient than CAD	4.2%	45.8%	50.0%	0.0%	0.0%
BIM is more effective than CAD	16.7%	37.5%	41.7%	4.2%	0.0%

Respondents also said the following:

“BIM is a better software but people in the architectural society (of India) are not aware of its capacities.”

“BIM is yet unknown to the students who join the office, plus there is a lot unpredictability in drawings which keep changing even when construction is happening

at the site. In that case, BIM tends to rather slow things down. Unless professionals who are well adapt with the software come in the market, its efficiency and effectiveness is of no use to Indian market at least.”

“I have not used BIM. I have only been oriented towards technology and realized its potential.”

“BIM is only useful if clients, consultants and skilled construction (e.g. pre-fabricated) use it. Also it is important to have highly skilled and trained BIM user to make, correct as well as edit it, hence, for low budget projects it is not feasible to use BIM in real time.”

13. The following statements list various strengths claimed for BIM and its implementation when compared to traditional methods. Please indicate your agreement with each statement. (23 respondents)

	Strongly Agree	Agree	Neither Agree Nor Disagree	Disagree	Strongly Disagree
BIM efficiency helps save time	21.7%	47.8%	30.4%	0.0%	0.0%
BIM accuracy helps save time	13.0%	47.8%	34.8%	4.3%	0.0%
BIM helps spend more time on design issues, rather than CAD or presentation issues	39.1%	39.1%	13.0%	8.7%	0.0%
BIM is easy to use	4.3%	47.8%	43.5%	4.3%	0.0%
BIM has thoughtful design features	9.1%	54.5%	36.4%	0.0%	0.0%
BIM allows better understanding for design	14.3%	47.6%	38.1%	0.0%	0.0%
BIM allows better presentation of design concepts to client (quick massing and rendering visuals)	34.8%	52.2%	8.7%	4.3%	0.0%
BIM's coordinated views and documents eradicate the fear of making last minute changes	34.8%	43.5%	17.4%	4.3%	0.0%
BIM allows better documentation with less errors	17.4%	47.8%	30.4%	4.3%	0.0%
BIM makes work less tedium	0.0%	54.5%	36.4%	9.1%	0.0%
BIM induces more confidence	4.8%	52.4%	42.9%	0.0%	0.0%
BIM forces designer to think three-dimensionally	13.6%	45.5%	40.9%	0.0%	0.0%
BIM eliminates the divide between designer and “CAD-person”	9.1%	36.4%	45.5%	4.5%	4.5%
BIM has the ability to capture specifications in the model	22.7%	36.4%	40.9%	0.0%	0.0%
BIM has built-in and accurate scheduling capabilities	18.2%	40.9%	31.8%	9.1%	0.0%
BIM allows user to work on a single 3D model rather than a multitude of separate 2D files	45.5%	45.5%	4.5%	4.5%	0.0%
BIM creates new opportunities in upcoming markets	18.2%	45.5%	36.4%	0.0%	0.0%
BIM facilitates Building Lifecycle Management (BLM)	13.6%	45.5%	40.9%	0.0%	0.0%

Respondents also made the following comments:

“BIM reduces the time of a project done as many features get done simultaneously.”

“As market is opening up to new and more complex ideas in architecture, the need to have BIM or any other model which integrates architecture and services is necessary for effective design development.”

“Many claims made by manufacturers are not converted to real time useful data, such as scheduling. It may take more time to actually set up schedules in BIM than to prepare them in Excel for example.”

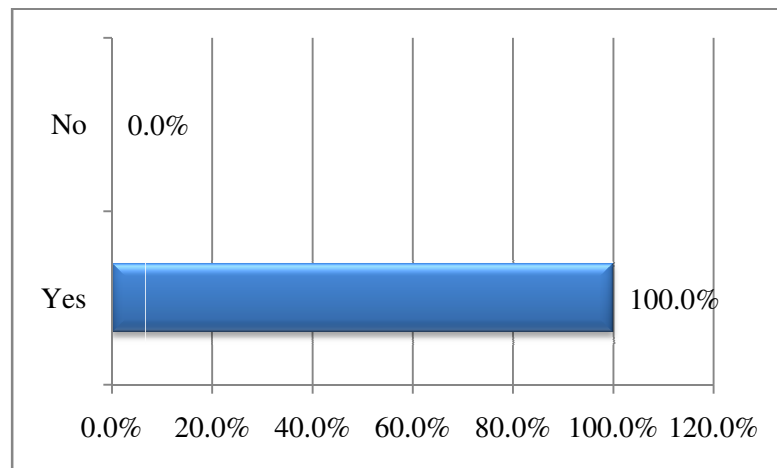
“BIM is an efficient tool - one of the many - and certainly not the ultimate one. The strength of BIM is not in its own capabilities, but in talking to other platforms with widely different capabilities.”

14. The following statements list various obstacles claimed for BIM and its implementation when compared to traditional methods. Please indicate your agreement with each statement. (21 respondents)

	Strongly Agree	Agree	Neither Agree Nor Disagree	Disagree	Strongly Disagree
Costly software has to be procured for BIM implementation	0.0%	61.9%	38.1%	0.0%	0.0%
Costly hardware has to be bought for BIM implementation	4.8%	47.6%	42.9%	4.8%	0.0%
Cost of training BIM to employees is high	9.5%	57.1%	33.3%	0.0%	0.0%
There are indirect costs of organizational/process/workflow changes as a result of BIM implementation	23.8%	57.1%	9.5%	9.5%	0.0%
There is professional resistance to the above changes	15.0%	30.0%	50.0%	5.0%	0.0%
BIM is a completely different interface than CAD	0.0%	47.6%	42.9%	9.5%	0.0%
There are incompatibility problems (file formats/standards/versions) in BIM	23.8%	42.9%	19.0%	14.3%	0.0%
BIM implementation initially affects the productivity	30.0%	50.0%	10.0%	10.0%	0.0%
Ample amount of time is required to learn application and customize according to company's standards	38.1%	42.9%	14.3%	4.8%	0.0%
BIM application faces sluggish performance of software and higher demand of computer resources	4.8%	47.6%	47.6%	0.0%	0.0%
BIM compels user to work on a single 3D model rather than a multitude of separate 2D files	28.6%	66.7%	4.8%	0.0%	0.0%
BIM requires lot of communication and collaboration	42.9%	42.9%	9.5%	4.8%	0.0%
BIM faces application programming interface (API) and customization problems	19.0%	52.4%	14.3%	14.3%	0.0%
BIM imposes resistance to rigor and honesty	4.8%	14.3%	9.5%	38.1%	33.3%
BIM has low ability for abstractions, especially during schematic/preliminary/conceptual design stage	4.8%	33.3%	38.1%	14.3%	9.5%
BIM lacks support for multi-disciplinary building design	0.0%	9.5%	47.6%	42.9%	0.0%

One respondent also pointed out that “a detailed model has to be prepared for all stages in BIM as compared to other 2D software where abstract/ less detailed options can be prepared.”

15. Was the questionnaire straightforward to complete? (22 respondents)



General findings were as follows:

1. Most of the architectural firms in India are small sized (1-10 people) and medium sized (11-50 people). In this scenario, the implementation strategy being developed by this directed project will be focused towards these two profiles of architectural firms.
2. 75% respondents to the survey had heard of Building Information Modeling (BIM) solutions and applications. Hence, Indian architects are not unaware of the latest technology and business processes. Further, 91.7% respondents believe that BIM usage increases the level of service, quality and performance of the architectural firm and not a single respondent disagreed with the same.
3. 48% respondents have used BIM solutions and applications at least once and only 66.7% of these still continue using BIM i.e. 32% of the total respondents.

4. 83.3% respondents have used BIM solutions and applications for less than 2 years. Hence, most of them have not reached a stage where they can see return on investment made on BIM.
5. An equal and high percentage of respondents are using Autodesk Revit and Google SketchUp (69.2%). Startlingly, architects consider Google SketchUp as BIM software, thus, raising doubts over their understanding of BIM.
6. 63.6% respondents had selected a small project as their BIM pilot project. Thus, Indian architects have been wise and started small.
7. 84.6% respondents use BIM solution in conjunction with Computer Aided Design (CAD). This shows that most of the BIM users are still trying to get a grip over the new system and technology and have yet not completely given away their old way of working. The good part is that 80% of the respondents are using three-dimensional (3D) CAD over two-dimensional (2D) CAD and nearly half respondents consider BIM to be faster, more efficient and more effective than CAD.
8. Surprisingly, a high number of Indian architects (45.8% of respondents) think that the owner will be willing to pay extra for BIM services, even though 75% think that the owners do not possess adequate knowledge of BIM and its various deliverables.
9. 45.5% respondents do not agree or disagree that BIM eliminates the divide between designer and “CAD-person” and 40.9% do not agree or disagree that BIM has the ability to capture specifications in the model. This can be because a

large percentage considered Google SketchUp to be a BIM interface and, hence, there can be a gap in the understanding of BIM.

10. BIM compels user to work on a single 3D model rather than a multitude of separate 2D files and, hence, 95.3% respondents consider that as an obstacle in BIM implementation.
11. 85.8% respondents think that high requirement of communication and collaboration by BIM is one of the important obstacles.
12. Incompatibility problems (file formats/standards/ versions) in BIM are faced by a huge percentage of respondents (42.9%). Also, 71.4% respondents have faced application programming interface (API) and customization problems with BIM and, thus, are hesitant in implementing BIM.

Conclusions

The architectural firms should leverage BIM to enhance the value of their services and extend the range of their core competencies, not just implementing BIM for the sake of it. They should soon realize tangible gains in productivity, team communication, and quality of service because of adopting BIM; they not wait for the rest of the industry to jump on the BIM bandwagon and should find ways to exploit BIM now.

BIM is set to become inherent to building design and construction. As the use of BIM accelerates, collaboration within project teams should increase and lead to improved profitability. Teams implementing BIM should be very careful about the legal pitfalls and address the same in contract documents.

Strategies Suggested

There is suddenly lot of expansion in the world of integrated architectural practice using BIM. Many architects can feel the pressure to implement BIM because of the above stated reason, where they end up doing so without much strategic planning, and thus, face daunting challenges. Architectural firms should improve upon decision-making within the firm and should plan with longer horizons and more flexibility, thus managing changes at a faster pace.

Principal architect of the firm needs to become information architect and strong project teams need to be built with good communication and knowledge sharing. For an architect to become a strong force in the economy, he needs to apply same level of creativity to business and delivery processes as he does to design. Today, there is a need to overlap and use technology with a comprehensive outlook since building data needs to be embedded and made accessible throughout facility's life cycle.

For producing better architecture and more satisfied clients, architectural firms need to utilize currently available resources and tools within the firm to deliver the advantages of BIM. Dependable information and decisions should be delivered by starting out right in the beginning, as going back and starting over again wastes lot of time and resources. Paul Adams, AIA, an architect from Denver has explained this best in his words: "All the big mistakes are made on the first day" (Jernigan, 2008). The quality of outcomes is affected by early decisions, thus, architects must ensure that traditional systems do not overshadow good business decisions with BIM processes.

The principal architects who will capitalize on the benefits of BIM and lay foundation for this substantive change will emerge as leaders in the industry. New and

evolving technology can lead to design, test and application of new tools in information management. Communication, integration, interoperability, certainty and knowledge are all essential principles in success of BIM implementation and application in architectural practice, thus, improving various design processes and widening their reach to integrate more processes. Also, architects become more valuable to clients by providing them dependable control.

Business Opportunities

Information sharing throughout the building industry is made possible because of BIM processes and the virtual models they result in. Not only do they transform the way architects do business, but they also place architects in the information age. Every architectural firm needs to leverage the information structure in the building information model to tap its real potential. To achieve the same, the firm's business competencies, objectives and strategies need to be critically evaluated. The same need to be connected to BIM implementation to reap its advantages; without this connection the transition might not happen at all. This transition within the company is difficult and expensive. Moreover, industry experts may resent this departure from their tried and tested methods of working and might not have confidence in this new technology.

Choosing Right Tools

The potential of the firms can be ameliorated by usage of correct software for building information modeling and the capabilities can detract if the company invests in a software solution which doesn't serve its building information modeling needs. The software chosen should enhance the architectural firm's design capabilities, increase its productivity, and streamline the workflow. One should focus on how to exploit BIM

technology to improve the present workflows, rather than adapting these workflows to suit the technology. Thus, the implementation strategy should emphasize the value of information exchange to support design processes.

Design firms should consider authoring tools which are optimized for building design and they needn't look further into those designed for construction and facility management. These can be one from Autodesk Revit, Graphisoft ArchiCAD, Bentley Architecture, or Nemetschek Vectorworks; though not limited to just the ones listed here. There are several packages available, each suitable and customized for a specific type of sub-industry within architectural design. The authoring tools can be complemented with audit and analysis tools for clash detection, energy analysis, cost estimation, etc., thus, adding value to architect's professional judgment and profits related to the project. The more the add-on technologies deployed, the further the firms are able to cut down cost and time while improving quality of output.

Innovation and Technology Management Strategies

Albert Einstein once said, "We cannot solve problems by using the same kind of thinking we used when we created them." It should be remembered that BIM is not only about buying the right software. It is about adopting processes and finding the best tools to deliver the highest value to the clients. It is complicated to embrace the changes within the firm if BIM is looked upon as just another software solution because the benefits will appear negligible. It is a progressive and transformative information based system that brings along long-term value and advances mutation between people's relation with a building project. BIM does not refer to an individual building model. It is a series of interlinked information models and information databases. Creation of digital databases,

usage of data by collaboration and capturing of knowledge for reuse are all made possible with BIM software.

Investment and Risks Strategies

The fact that cost of the software constitutes a small part of firm's total investment in BIM is often ignored, especially in architectural firms because they usually do not measure the return of investment in BIM. This leads to incorrect and inaccurate decisions in company's strategy formation. As compared to CAD technology, BIM technology is easier to align with an architectural firm's practices and workflows and the return on investment is much easier to measure.

Building information modeling as a technology shouldn't be evaluated on the basis of its acquisition cost. Principal architects should look into the full implementation costs and full revenue generating potential of the technology being adopted. Software licensing and training should be looked at as components of a large strategic investment that'll produce a measurable financial return. From a broader perspective, the software is a commodity to be consumed and used, not just to be invested in.

Team Capability Assessment

Profitability of BIM to architects can be increased by increasing efficiency and productivity within the design team and thus exhibiting increased value from BIM to their clients. Perception of services needs to shift from cost-based to value-based. BIM training needs to precede or accompany BIM education. Hence, greater productivity can be achieved by BIM education (not just BIM software training), thus, reforming the business culture and processes. The cultural transformation is a bigger challenge than the technological transformation for the architectural industry. Finally, information

stewardship and frequent information exchange will lead to a transparent and collaborative culture.

Project team capabilities need to be assessed for collaboration and exchange capabilities within the team. Each team member's set of responsibilities and information handled by each are also looked into. How this individual information flows through the design team determines opportunities and platforms for information exchanges and points out overlaps and redundancies to be eliminated. The number of employees who understand what BIM is and believe in the change of technology and business processes should be steadily increased. The number of alliances with architects and team-members focused on similar goals should be expanded by knowledge sharing, thus, enhancing the performance associated with BIM. With BIM, architects get more time to do things they like to do and mechanize the routine. Thus, the transition from CAD to BIM has an instantaneous impact on the architectural business, adding value and relevance to this field of AEC industry.

Cultural Change Management

Principal architects should aim at testing various workflows and practices, gaining insight from these series of experiences and modifying the firm's approach by continuously innovating. This enables for more flexibility, experimentation and organic development of technology. The building industry is fragmented, hidebound and litigious, but our existing business systems are still not so deeply entrenched that we lack the power to bring about a change. Information modeling is more about designing a reliable system assisting in compilation and exchange of information in a culture of

information stewardship, and has less to do with individual software applications. It revolutionizes the business system and the way of thinking.

Similarly, progress towards strategic goals needs to be measured while deploying this new technology, though metrics can be difficult to establish in a case like this with unknown element. It might not be convenient to quantify every goal and metric in terms of money, but the same is not impossible either. The results of BIM implementation will be better if there is a stronger connection between the strategy for the same and profitability.

Since BIM makes an attempt at reducing the mundane and working smarter with less effort, it needs a completely different mindset at work and a diverse training regimen for the same. Architects need to develop, explore and understand new insights, roles and viewpoints where right set of skills need to be applied to the right elements at the right time in the decision-making. Cooperation, collaboration and mutual support need to be fostered, while fragmentation, duplication and adversarial relationships need to be decreased, by making efforts to define new systems whose ability to advance and compete should not be undermined.

For driving change in the architectural industry, we require technology with the ability to deliver better, faster, cheaper projects and processes to meet the owner's demands. This leads to phenomenal savings and efficiencies earned by those principal architects who rethink their existing business process and embrace changes to take advantage of new technologies. Also, architects should avoid making decisions with too little information available. A strategy for adapting emerging tools and systems and using them profitably needs to be created for the architectural firms. But since BIM is all about

getting results in the present, the focus should be laid on using the tools and processes that work well currently. BIM processes aim at keeping the processes simple and not having magnanimous goals. All the information is added as soon as it is available and analyzed alongside, rather than waiting for all the information and every related detail to be completely added and later scrutinized.

Business Process Reform Strategies

Till most of the design and construction industry has made a transition to BIM, the architectural firms adopting this new technology and business practice need to determine an extent to which BIM can be profitably integrated into their operations. Full benefits can be reaped only after whole industry implements BIM, because our industry has a broad network of people and firms working together, exchanging interlinked and interdependent information. Individual firms develop best practices and assume innovation risk, thus standing out of the crowd, because of competition. But if these best practices need to be followed in entire industry, they need to be widely shared and adopted. The principal architects need to manage this change and the risks associated with the same.

Firms unable to meet new demands of market end up waiting too long for this change and are left with significant competitive disadvantage. These firms embrace innovation into their business practices only when they realize that they've now become a convention. Other firms explore various possibilities in technology and innovation, thus, not following the safest strategy of going with tried and tested. This practice not only gives tangible results in few, but also the brand-name benefit.

This is a time when architectural firms can start implementing BIM and learn lessons that the pioneers have learnt by starting ahead of the curve. While significant opportunities still let them differentiate themselves from the competition, implementation at this point of time alleviates high risks posed by experimentation with new technology. Every kind of organization needs to adapt to change merely to sustain and regenerate itself, as the economy is recurrent and technology is changing. Core competencies can be strengthened, services offered broadened, workflow streamlined, quality of work increased, costs lowered, team communication improved, electronic information exchange enhanced – all by identifying new practices and technologies.

Only technologies requiring minimal customization should be utilized. Non commercial/experimental technologies should be avoided. If necessary, they should be checked for demonstrated track record of success. Participation in beta testing programs should be done keeping in mind that it requires help in developing software and needs technical expertise. Financial investment, education and training are a part of this transitional phase. The productivity may temporarily drop. As a firm, culture of innovation needs to be fostered.

Conventional Practices Reform Strategies

Low value tasks (such as RFIs, shop drawings, etc.) should be reduced to decrease cycle time. Cost estimating should be integrated with BIM to generate more accurate and detailed estimates early on in the project. Constructability analysis and sequence planning should be done using BIM. Detailed comparative analysis between various design options is possible, thus, improving the quality of future designs. Information, and not just technology, needs to be used to improve the way these architectural firms do business.

Business leaders need to consider information authorship as an important aspect of business practices, where the most logical authentic source should be referred for information. Information flow should be analyzed regularly and data retrieval and validation should be done by deploying systematic procedures. Since there is aversion for creating information in a building information model, as compared to the anticipation to use the information, information gathering needs to be integrated into business process. Since maintaining the model is looked upon as extra work, keeping the model up-to-date consistently requires firm amalgamation of data collection and compilation activities.

Principal architects for firms need to form a vision for their firm, which should define goals, objectives, tasks, and metrics for measuring progress towards the goals. Appraisals and performance evaluations will help in maintaining the momentum with help of effective leadership. Failures in business process reforms are usually because of failed implementation and not due to failed processes. Other times, these failures are result of acknowledgment of need for change but incapability to understand how to bring about this change.

Modeling of business practices is an important part of change management and can be handled using various approaches which already have documentation available. Two common methods used for modeling BIM practices are Integrated Definition modeling (IDEF) and Business Process Modeling Notation (BPMN). BuildingSMART International and U.S. National BIM Standard (NBIMS) Committee have shown an inclination towards BPMN up till now, though Microsoft Visio Professional supports graphical representation of both methods. Business process modeling needs to determine

which information needs to be incorporated into BIM and which is needed just for the working practices.

Database normalization should be adhered to, i.e. only the most authoritative author should be assigned the task of entering a specific data exactly once during the building life cycle. All relevant information should be collected the first time, in detail. The most organized electronic structure should be followed for sending and receiving data to same pre-processing. Also, industry-wide open standards should be adopted as far as possible.

National Building Information Modeling Standard Capability Maturity Model

The National Building Information Modeling Standard (NBIMS) has developed the Capability Maturity Model (CMM) as a step towards establishing BIM implementation benchmarks and, thus, measuring the maturity of any building information model and the processes used in the creation. (National Institute of Building Sciences, 2007). From the broader perspective, NBIMS CMM is a Capability Maturity Index since it is an index to measure maturity of a firm's BIM capabilities on the basis of eleven categories, on a scale of one to ten. (Refer to Appendix B for details about NBIMS CMM)

Successful BIM Implementation

BIM needs to align with the company's goals, to make it more successful in the future.

1. A project engineer responsible for creating and managing BIM and facilitating all processes related to the same needs to be identified as BIM manager for that project. He must possess understanding of project workflows and project

management with technical knowledge of BIM. Remember, BIM doesn't work, people make it work. (Gallelo, 2008)

2. Software packages should be critically assessed in detailed manner to decide which application's capabilities suit the firm's goals and requirements from BIM, instead of going for the software everyone is using. Just the way following the market assures no huge losses, it can yield only marginal profits. Architectural firms can also deploy pre-design tools to accelerate, automate or streamline decision-making and information-accumulating processes.
3. Initially a small group of people with BIM manager and associates from specific divisions working on BIM implementation should be trained. This group returns to use the software soon after the training and starts producing work, using the newly learnt software.
4. BIM manager should be trained in all BIM software used by the company to understand purpose of each and keeping the company aware of new technologies, methods, and resources through him.
5. Internal resource building needs to be done by developing tutorials, standards, guides, etc. accessible to team members.
6. Manual data entry should be decreased to minimum extent and gradually eradicated, to bring in electronic information exchange. Business processes should be reorganized such that more tasks occur concurrently than sequentially.
7. Emphasis should be laid on importance of data collection and its quality. Data entry and its maintenance tasks should be integrated into the architectural firm's workflow and business processes.

8. BIM is an investment. A time and cost estimate for implementation and usage of BIM software needs to be developed. The software and hardware acquisition plan needs to give the management an idea of the summary of investment needed and rationale for every item's use, for securing ownership buy-in.
9. Long-term business strategy needs to be proactively created by architects for developing and operating future resources where design and implementation can work in parallel.
10. An integration plan amalgamating software acquisition plan, training schedule, hardware update schedule, explanation of technological shift, and strategy roll-out plan needs to be developed to determine efficiency of new systems as a yardstick.
11. Small firms should try to become more effective and make more profit by determining changes that will enable them to take one-step at a time towards an integrated practice. Medium-sized firms need to retain the business processes that work for BIM and replace the rest by moving beyond just procuring new applications and software, thus, developing their firm's business processes for this change. A detailed roadmap for organizational change management process needs to be developed and followed only in large established firms.
12. The company needs to stick to the plan during the implementation phase by purchasing software on time and training associates in software relevant to their field. At the same time, the company needs to remain flexible and adapt to better alternatives when they become available, as they still focus on similar milestones as before.

13. Implementation needs to be measured by analyzing savings and value created by BIM. Emerging business practices and technological advances should be continuously evaluated to develop critical framework. Metrics should be recognized while deploying new technology to measure progress towards company's goals and ROI.
14. New software proposals and industry trends need to be monitored constantly, thus, continually seek improvement. Management might prefer procuring software which give them higher efficiency, better revenue and competitive edge.
15. The existing information storage, retrieval and exchange capabilities of the firm will need to be critically assessed, especially for IFC-compliance. Data creation also needs to be maintained, filed, indexed and documented. Conventions need to be developed and followed for the above processes. Hence, information modeling requires great deal of information management to reap early results. Pilot testing needs to be considered as an important component in developing mutual information assurance this transition requires.
16. As the survey also confirms, owners realize the savings from using BIM, and most owners are starting to recognize this and are willing to reimburse project teams for upfront costs. BIM implementation gives an opportunity for owners to collaborate with contractors and design team to coordinate the whole construction process and optimize its value. (Jones and Womack, 2002) The internal development on the project can be monitored by the owner by utilizing BIM tools in various phases of the project.

Recommendations

Through the completion of this directed project it has become clear about how to implement BIM in architectural firms in India. As we found out through our survey, a high number of Indian architects assume that the owner will be willing to pay extra for BIM services, even though they currently do not possess adequate knowledge of BIM and its various deliverables. Future studies may be performed on making the owners realize and utilize the potential BIM holds for them. In a country where there is lot of competition especially on the cost-front, BIM makes sure that more of owner's money goes into the building than the administrative, documentation and overhead costs. This is an area where additional studies may yield valuable results. Also, investigation can be done to find out if the architectural firms realize that BIM reduces the project team size, thus, lowering the firms' IT infrastructure costs and real estate costs incurred by them. Last but not the least, research can be done on how much percentage of project cost is spent on the digital models and BIM technology by various teams involved in it.

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Appendix A

1. Please select the nature of your firm: (Select all that apply)
 - a. Architectural
 - b. Engineering
 - c. Construction
 - d. Others (Please specify)
2. How many people work in your firm?
 - a. 1-10
 - b. 11-50
 - c. 51-100
 - d. 101-200
 - e. 200-500
 - f. More than 500
3. Have you heard of Building Information Modeling (BIM) solutions and applications?
 - a. Yes
 - b. No
4. Have you ever used BIM solutions and applications?
 - a. Yes
 - b. No
5. If the answer to Question#4 is NO, please skip questions 5-14. If YES, are you still using BIM solutions and applications?
 - a. Yes
 - b. No
6. For approximately how many years have you used BIM solutions and applications?
 - a. 0 – 1 year
 - b. 1 – 2 years
 - c. 2 – 5 years
 - d. More than 5 years
7. Which software vendor(s) do you use/have used for BIM? (Select all that apply)
 - a. Autodesk Revit
 - b. Graphisoft ArchiCAD
 - c. Autodesk Navisworks
 - d. Google SketchUp
 - e. Bentley MicroStation
 - f. VectorWorks
 - g. Vico
 - h. Tekla
 - i. Others (Please specify)

8. What was the size of your pilot BIM project? (A pilot project refers to an initial roll out of a system)
 - a. Small (value less than \$1 million)
 - b. Medium (value between \$1 and \$5 million)
 - c. Large (value more than \$5 million)
9. Was the pilot BIM project first-of-its-kind for your firm?
 - a. Yes
 - b. No
10. Do/did you use BIM solution in conjunction with Computer Aided Design (CAD)?
 - a. Yes
 - b. No
11. Which of the following CAD applications are you using currently?
 - a. Two-dimensional (2D) CAD
 - b. Three-dimensional (3D) CAD
12. Please respond to the following statement:

	Strongly Agree	Agree	Neither Agree Nor Disagree	Disagree	Strongly Disagree
Clients are willing to pay extra for BIM services					
Our clients possess adequate knowledge of BIM and its various deliverables					
BIM is useful for different design and documentation tasks					
BIM usage increases the level of service, quality and performance of the architectural firm					
I am satisfied with BIM software and capabilities					
It is easy to learn and use BIM software					
BIM is faster than CAD					
BIM is more efficient than CAD					
BIM is more effective than CAD					

Please use the space below to explain your choices and/or to make comments.

13. The following statements list various strengths claimed for BIM and its implementation when compared to traditional methods. Please indicate your agreement with each statement.

	Strongly Agree	Agree	Neither Agree Nor Disagree	Disagree	Strongly Disagree
BIM efficiency helps save time					
BIM accuracy helps save time					
BIM helps spend more time on design issues, rather than CAD or presentation issues					
BIM is easy to use					
BIM has thoughtful design features					
BIM allows better understanding for design					
BIM allows better presentation of design concepts to client (quick massing and rendering visuals)					
BIM's coordinated views and documents eradicate the fear of making last minute changes					
BIM allows better documentation with less errors					
BIM makes work less tedious					
BIM induces more confidence					
BIM forces designer to think three-dimensionally					
BIM eliminates the divide between designer and "CAD-person"					
BIM's ability to capture specifications in the model					
BIM's built-in and accurate scheduling capabilities					
BIM allows user to work on a single 3D model rather than a multitude of separate 2D files					
BIM creates new opportunities in upcoming markets					
BIM facilitates Building Lifecycle Management (BLM)					

- Please use the space below to explain your choices and/or to make comments.
14. The following statements list various obstacles claimed for BIM and its implementation when compared to traditional methods. Please indicate your agreement with each statement.

	Strongly Agree	Agree	Neither Agree Nor Disagree	Disagree	Strongly Disagree
Costly software has to be procured for BIM implementation					
Costly hardware has to be bought for BIM implementation					
Cost of training BIM to employees is high					
There are indirect costs of organizational/process/workflow changes as a result of BIM implementation					
There is professional resistance to the above changes					
BIM is a completely different interface than CAD					
There are incompatibility problems (file formats/standards/ versions) in BIM					
BIM implementation initially affects the productivity					
Ample amount of time is required to learn application and customize according to company's standards					
BIM application faces sluggish performance of software and higher demand of computer resources					
BIM compels user to work on a single 3D model rather than a multitude of separate 2D files					
BIM requires lot of communication and collaboration					
BIM faces application programming interface (API) and customization problems					

BIM imposes resistance to rigor and honesty					
BIM has low ability for abstractions, especially during schematic/preliminary/conceptual design stage					
BIM lacks support for multi-disciplinary building design					

Please use the space below to explain your choices and/or to make comments.

15. Was the questionnaire straightforward to complete

- a. yes
- b. no

Please provide suggestions about how to improve the questionnaire.

Appendix B



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Chapter 4.2 Capability Maturity Model

Introduction

The electronic version of the Capability Maturity Model workbook may be downloaded at: <http://www.facilitiesinformationcouncil.org/bim/i-CMM>. This will also provide a more readable copy than what is able to be displayed in this document.

The objective of NBIMS and embedded IFC Initiative is to take the next step in technology infusion to transform the building supply chain through open and interoperable information exchange. In this standard, the group of stakeholders in the BIM discussion is referred to as the Architect/Engineer/Constructor/Operator or Owner (AECO) community. To meet the future needs of a more streamlined AECO community and build on existing best business practices, a Capability Maturity Model (CMM) has been developed for users to evaluate their business practices along a continuum or spectrum of desired technical level functionality. The concept of a CMM may be familiar to software developers who create, test, field, and update their software,³² but the CMM included here is not targeted at software designers. On the contrary, most of NBIMS consists of high-level doctrine or lessons learned regarding BIM, but the CMM is one of the items targeted at the AECO industry for immediate use and application on current processes or BIM projects. The vision is that stakeholders will use the CMM as a tool to plot their current location, while looking to more robust parts of the spectrum as goals for their future operations.

WARNING: While we recognize the temptation, it is not intended for the Capability Maturity Model to be a measure of a company's BIM capability for marketing purposes and use for that purpose is highly discouraged. However, when implemented, stating that a company uses the National BIM Standard will be encouraged.

Tabular CMM

Tabular BIM Capability Maturity Model

Activity Level	1	2	3	4	5	6	7	8	9	10
1. Business Strategy	Business Plan	Business Plan	Business Plan	Business Plan	Business Plan	Business Plan	Business Plan	Business Plan	Business Plan	Business Plan
2. Project Planning	Project Planning	Project Planning	Project Planning	Project Planning	Project Planning	Project Planning	Project Planning	Project Planning	Project Planning	Project Planning
3. Information Management	Information Management	Information Management	Information Management	Information Management	Information Management	Information Management	Information Management	Information Management	Information Management	Information Management
4. Data Exchange	Data Exchange	Data Exchange	Data Exchange	Data Exchange	Data Exchange	Data Exchange	Data Exchange	Data Exchange	Data Exchange	Data Exchange
5. Data Integration	Data Integration	Data Integration	Data Integration	Data Integration	Data Integration	Data Integration	Data Integration	Data Integration	Data Integration	Data Integration
6. Data Analysis	Data Analysis	Data Analysis	Data Analysis	Data Analysis	Data Analysis	Data Analysis	Data Analysis	Data Analysis	Data Analysis	Data Analysis
7. Data Visualization	Data Visualization	Data Visualization	Data Visualization	Data Visualization	Data Visualization	Data Visualization	Data Visualization	Data Visualization	Data Visualization	Data Visualization
8. Data Collaboration	Data Collaboration	Data Collaboration	Data Collaboration	Data Collaboration	Data Collaboration	Data Collaboration	Data Collaboration	Data Collaboration	Data Collaboration	Data Collaboration
9. Data Interoperability	Data Interoperability	Data Interoperability	Data Interoperability	Data Interoperability	Data Interoperability	Data Interoperability	Data Interoperability	Data Interoperability	Data Interoperability	Data Interoperability
10. Data Reuse	Data Reuse	Data Reuse	Data Reuse	Data Reuse	Data Reuse	Data Reuse	Data Reuse	Data Reuse	Data Reuse	Data Reuse

Figure 4.2-1 CMM Chart (Courtesy NIBS)

³² For specific information, see <http://www.sei.cmu.edu/cmm/> or read *Capability Maturity Model: Guidelines for Improving the Software Process*, Software Engineering Institute, Carnegie Mellon University, ISBN: 0-201-54664-7, 1995. Hardcover, 464 pages, 2006.



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There are two versions of the BIM CMM included in NBIMS. The first is called the tabular CMM because it is a static Microsoft Excel® workbook consisting of three worksheets with information that lists the information in a true spectrum. The second is the interactive CMM which consists of a multi-tab Excel workbook that is based on the tabular version, but is different because it interacts with the user as information is entered into the user interface. It is envisioned that the CMM will be web-enabled and served off the NIBS-FIC website, but the Excel file is a low-tech, user friendly way to deliver the same functionality. Both of these two versions of the CMM will be explained here in order of their worksheet tabs in their respective workbooks in Microsoft Excel.

1. CMM Chart

As seen in the screen capture, Figure 4.2-1, the CMM is a matrix with an x-axis and a y-axis. On the x-axis, you see 11 areas of interest, in no particular order. On the y-axis, you see maturity levels from 1 to 10 with 1 being the least mature and 10 being the most mature. The body of the matrix puts into words varying levels of maturity describing the areas of interest in an organization or on an individual project. Since the words are subjective and open to interpretation, it is likely that no two people will always agree on all the possible divisions or descriptions of the varying levels of maturity, but they represent a simplified consensus-based approach. In this way, a large number of items are structured in a way that people can use as a launching point for classifying themselves on a somewhat standardized continuum. Finally, it is understood that these descriptions will be updated as the community progresses and greater levels of BIM adoption dictate.

2. Descriptions

Weight	Title	Description
11	Data Harvest	Identifies the completeness of the building system model from actively being harvested or captured during the point of it becoming available information and fully being corporate knowledge about it fully.
11	Life-cycle View	Views refer to the phases of the project and identifying how things, places, are to be covered by the BIM. One would not see individual view point of information and then begin taking these together and using advanced information gathered by the individual view scores of the information. This category has high cost reduction, high value implications based on the utilization of duplication data gathering. The goal would be to support functions provide the traditional facility management tasks, such as first maintenance.
12	Rules Or Discipline	Focus refers to the design environment, the business process and how the information flows. This is also related to reducing the cost of data re-utilization. Discipline another term within more than one view so either supplier or consumer of information. Our goal is to reduce both internal and external costs as both providers and consumers of the information so that data does not have to be re-created and thus the value added to the data provider or the information.
12	ITIL Maturity Assessment	Information Technology Infrastructure Library provides a set of best practices approaches to information management. Using these best practices is not just a checklist, it is a framework that everyone is working to converge their efforts and become unified. It is not just the data, it is procedures to modify the problems.
13	Business process	The business process defined how business is accomplished. If the data and information is gathered as part of the business process then data gathering is a non-cost requirement. If data is gathered as a one-time process then the data will be more expensive. The goal is to have data both collected and maintained in a real time environment, so as digital changes are made they are reflected for other business process in real time or the business process.
13	Timeliness Response	While cost reduction is a more static then other information, all changes and up to the minute accuracy is required in emerging situations. The data is accurate and the information provides the better quality information that is needed. Some of these decisions may be for strategic value.
14	Collaboration	Data delivery is also critical to success. If data is only available once then the sharing can not occur other than a manual hard copy. In a structured network environment if information is centrally stored or accessible then some sharing will occur. If the model is a system defined architecture (SDA) in a well-defined environment then non-compatibility will occur and information will not be in a structured environment to the appropriate type of information architecture that is required for all phases.
15	Graded Information	Over the starting point of a non-graded environment. The system or graded help point is a dense picture for all involved. As standards are applied the information can begin to flow as the provider and consumer have the data standards applied. As 3D images enter into the system consumers of the information will have a common view and higher level of understanding will occur. As time and cost are added then the information can be expanded significantly.
16	Spatial Capability	Understanding where something is in space is a significant for emerging information systems and the delivery of the information. Energy calculations must know where the heat gains will come from, for example need to know where water supply and utility utility are located in relation to the facility.
17	Information Accuracy	Having a way to ensure the information is accurate is only possible through some mechanism to provide the capability, adding a higher production will also allow to better manage the supporting data to give context. These numbers can be used for accounting, information collection, compliance and environmental calculations.
18	Interoperability IFC Support	The ultimate goal is to ensure interoperability of information. Having accurate information is the primary purpose of the information. There are many ways to ensure this, however the most effective is to use a standards based approach to ensure the information is accurate that it can be shared and problems are avoided that are not the standard of information.

Figure 4.2-2 Descriptions (Courtesy of NIBS)



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As the screen capture, Figure 4.2-2, shows, the descriptions tab lists and describes all the areas of interest in weighted order in a tabular format. In the Description column, the text is primarily focused on the philosophy of the area of interest as well as setting the stage for what conditions are usually more preferable. For example, under the Information Technology Infrastructure Library (ITIL)³³ Maturity Assessment, it alludes to best business practices or processes for storing and finding information. Complying with this area of interest will first require ITIL awareness, followed by varying levels of excellence along the continuum of control, integration, or optimization. As was said earlier, this will need to be updated as times and terms dictate.

Interactive CMM (I-CMM)

As described above, the interactive CMM is based off the tabular CMM and, as such, it contains all the same information as the tabular CMM, but it centers on a graphical user interface that makes the static information come to life, in a way that may be more easy to digest and understand for some users. Just as the descriptions of the tabular CMM were listed according to their tab number and title in their workbook, so will the tabs of the interactive CMM be described here.

The Interactive BIM Capability Maturity Model				
Area of Interest	Weighted Importance	Choose your perceived maturity level		Credit
Data Richness	84%	Expanded Data Set		7.7
Life-cycle Views	84%	No Complete		0.8
Change Management	90%	No ITIL Imp		0.9
Roles or Disciplines	90%	Two Roles Part		2.7
Business Process	91%	Few Bus Proces		7.8
Timeliness/Response	91%	Most Response Info		7.8
Delivery Method	92%	Network Acces		2.8
Graphical Information	93%	NCS 2D Non-Intell		2.8
Spatial Capability	94%	Not Spatial		0.9
Information Accuracy	95%	Initial Ground Truth		7.9
Interoperability/ IFC Support	96%	Forced Interoperability		7.9
Credit Sum				20.1
Maturity Level				Minimum BIM

Figure 4.2-3 Interactive Maturity Model (Courtesy of NIBS)

Hovering over each area of interest will elicit a comment with the full description of that area of interest.

1. Interactive Maturity Model

The first, and primary, tab of interest, see Figure 4.2-3, in the interactive maturity model workbook is the tab, Interactive Maturity Model. This interface's mission is to turn the tabular chart, which is successful in showing all the information at once in a matrix format, into an interface that users can interact with to self-evaluate their own processes or BIMs. The areas of interest are listed in the first column, in increasing order of perceived importance.

³³ In the 1980s, the UK asked what is now the Office of Government Commerce (OGC) to develop an approach for efficient and cost-effective use of IT resources by British public sector organizations. The aim was to develop an approach independent of any supplier. This resulted in the ITIL. For more information on ITIL, read: *Introduction to ITIL*, ISBN 0113308663, Published by the Stationery Office, 2002.



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Points Required for Certification Levels		
Low	High	
20	29.9	Minimum BIM
30	39.9	Minimum BIM
40	49.9	Minimum BIM
50	59.9	Certified
70	79.9	Silver
80	89.9	Gold
90	100	Platinum

In 2008, the Minimum BIM requires 30 points

Figure 4.2-4 Highlighted, Date-Sensitive Minimum BIM levels (Courtesy of NIBS)

The next column shows the relative percentage out of 100% that each area of interest garners, see Figure 4.2-4. After that, users will choose their own perceived maturity levels by employing the drop-down menus aligned with each area of interest. When clicking on this cell, the dropdown text reminds you of the definition of the area of interest, so that you may make an informed choice among ten levels of maturity. After choosing the correct level of maturity in the desired area of interest, the amount of credits automatically appears in the next column. Together, these credits are summed in the TOTAL box, which in turn determines the level of certification achieved. The varying levels of certification from simply 'Minimum BIM' to 'Platinum,' and they are listed below in the ADMINISTRATION section. It is important to note that the Minimum score required for a Minimum BIM is dependent on the date that the interface is used, which automatically is known as soon as the user opens the interface. If the date is 2008, the minimum score required for the distinction of 'Minimum BIM' is 30 points. If the date were 2009, it is 40 points, and so on to allow for future education and BIM improvements industry-wide.

The Interactive BIM Capability Maturity Model			
Area of Interest	Weighted Importance	Choose your perceived maturity level	Credit
Data Richness	8%	Expanded Data Set	1.7
Life-cycle Views	8%	No Complete Project Phase	0.8
Change Management	8%	No IML Implementation	0.9
Roles or Disciplines	8%	Two Roles Partially Supported	2.7
Business Process	8%	Few Bus Processes Collect Info	1.8
Timeliness/Response	8%	Most Response Info manually re-collected	1.8
Delivery Method	8%	Network Access w/ Basic IA	2.8
Graphical Information	8%	NCS 2D Non-Intelligent As Designed	2.8
Spatial Capability	8%	Not Spatially Located	0.9
Information Accuracy	8%	Initial Ground Truth	1.9
Interoperability/IFC Support	8%	Forced Interoperability	1.9
Credit Sum			20.1
Maturity Level			Minimum BIM

Points Required for Certification Levels		
Low	High	
20	29.9	Minimum BIM
30	39.9	Minimum BIM
40	49.9	Minimum BIM
50	59.9	Certified
70	79.9	Silver
80	89.9	Gold
90	100	Platinum

Remaining Points Required For:	Certified	29.9
--------------------------------	-----------	------

Hyperlinks	
Interactive Maturity Model	
Area of Interest Weighting Flowchart	
Interactive Maturity Model	
Category Descriptions	
Main Overview	

Figure 4.2-5 Completed View (Certification Level = Minimum BIM)(Courtesy of NIBS)

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All Certified scores, see Figure 4.2-5, currently stay the same regardless of date. The certification scores are similar to most academic grades, with a maximum possible, weighted score of 100 points. Some added user-friendly features include the area that shows the *remaining points required* to reach the next level of certification, as well as hyperlinks to other tabs of functionality within the workbook.

2. Area of Interest Chart

The Area of Interest Chart, see Figure 4.2-6, is tied to the credits column on the first tab of the application. Therefore, every time a perceived maturity level is selected, its credits are listed on the first tab but graphed on this tab. In this way, users can easily see where their operations are the most mature.

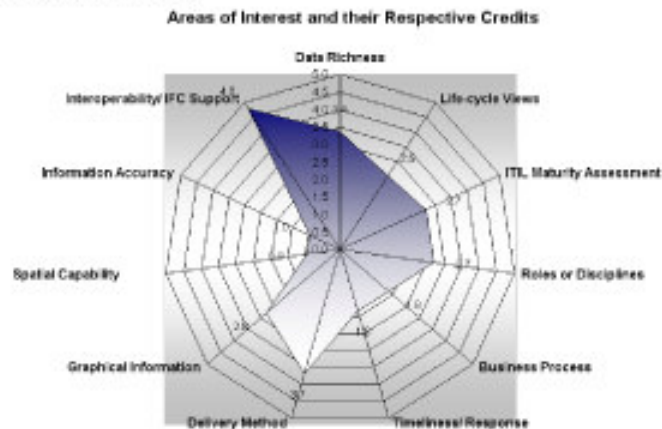


Figure 4.2-6 Areas of Interest and their Respective Credit Chart (Courtesy of NIBS)

3. Area of Interest Weighting

The next tab, see Figure 4.2-7, the Area of Interest Weighting tab shows a hierarchical decision tree of the weighting of the different areas of interest. Were your organization to disagree with the existing weighting scheme, you could use this as a launching point for creating your own weighting scheme and edit the application to reflect your own preferences. However, as the community grows and best business practices are achieved, the hope is for a national consensus on the appropriate level of weighting for the 11 areas of interest.



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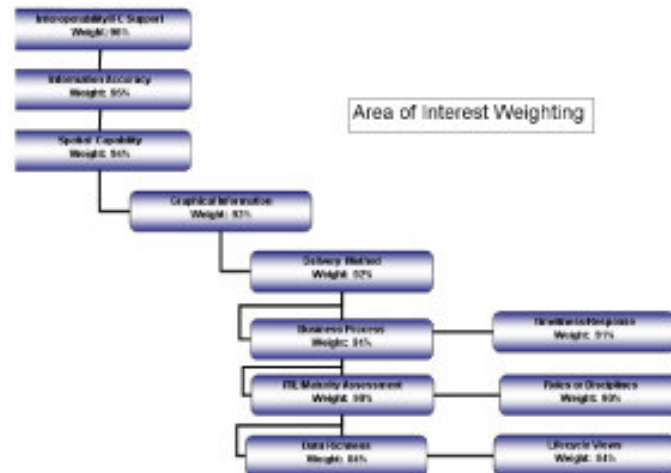


Figure 4.2-7 – Area of Interest Weighting Hierarchy (Courtesy of NIBS)

4. Tabular Maturity Model/Category Descriptions

The Tabular Maturity Model and Category Descriptions tabs are the same information as described above in the Tabular CMM portion of this section. The same information is also included in this application so that users may see their information in as many ways as necessary to help them establish a metric for establishing and evaluating their own maturity level.

I-CMM Testing and Evaluation

In order to ensure that the I-CMM could be used to successfully convert subjective case-by-case ratings into an objective quantitative score, the NBIMS Testing Team undertook a test bed validation of the NBIMS I-CMM in the summer of 2007. With the approval of the American Institute of Architects, Technology in Architectural Practice (AIA-TAP) Community of Practice, the winning 2007 BIM Award submissions were evaluated using the I-CMM. Six NBIMS Testing Team Members evaluated the nine winning submissions. Because the test was focused on validating the I-CMM and not on the already proven superior quality of the BIM models themselves, special attention was focused on the ability of the individual evaluators to replicate similar scores without any influences from the other evaluators.

The results yielded no more than a 5% difference in the various scores of the evaluators on the same BIM, and normally resulted in a 1% (or only 1 point out of 100) difference when the evaluators used the I-CMM to analyze the different BIM submissions.

The team noted that the I-CMM is primarily focused on leveraging information management, rather than architectural, engineering, construction, or management metrics. Accordingly, the BIMs scored received a wide range of scores commensurate with their project requirements. Logically, the highest scoring BIM submission was a test bed BIM pushing the edge of current interoperability, while the lowest scoring BIM (which received a 'Minimum BIM' rating) was for a custom-designed residential home. Therefore, it is important to note that the I-CMM is very effective at measuring BIM information management, but it should not be used as a benchmark for any other metrics. In other words, just as owners' needs do not require that every building be



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built to LEED-Platinum standards, neither should any BIM be perceived as less successful if it does not achieve an I-CMM Platinum score.

Further testing work has been accomplished with similar successful results at locations such as the Army Corps of Engineers Seattle and Louisville Districts on their test bed BIM projects; however, like NBIMS itself, the I-CMM will need to be updated according to industry capabilities and needs.

Conclusion

The purpose of the National BIM Standard Committee is to knit together the broadest and deepest constituency ever assembled to address the losses and limitations associated with errors and inefficiencies in the building supply chain. A BIM should access all pertinent graphic and non-graphic information about a facility as an integrated resource, but there are varying levels of maturity when pursuing this goal. The goals of the two Capability Maturity Models, both tabular and interactive, are to help users gauge their current maturity level, as well as plan for future maturity attainment goals through a commonly accepted, standardized approach. As industry evolves and more rapidly adopts greater levels of maturity, this model will change to accurately reflect best industry practices.

Next Steps

The NIBS-FIC Business Process Integration Task Team (BPITT) hopes to provide web-enabled publication support of the interactive maturity model. This currently notional web-based interface should provide a means for both certifying BIM products (such as specific models) and accrediting individual professionals for demonstrating knowledge in the information and processes outlined in NBIMS. A diagram of the proposed, added functionality of this notional web interface looks like Figure 4-2.8.

In this way, people would be motivated to learn the information in NBIMS because they could enjoy the recognition that accreditation would provide. The NBIMS Committee would benefit from having followers who could accurately relay correct information about proper BIM/IDM methodology. Furthermore, projects receiving certification would provide discriminators for forward-looking companies to demonstrate their ability to comply with proper NBIMS operations for the AECO community, which could help them win jobs or build respect in their fields. The corollary benefit would be that every certified BIM would go to a repository of information that the NIBS-FIC could mine for data regarding maturity or best business practices. This empirical data would provide trends that could easily be converted to lessons learned the BPITT could leverage in recommending or shaping future business practices.

While the information above is merely proposed, one thing is certain: This is the inaugural version of the BIM Capability Maturity Model and much work remains to be done in order to mature it to be a fully integrated product.

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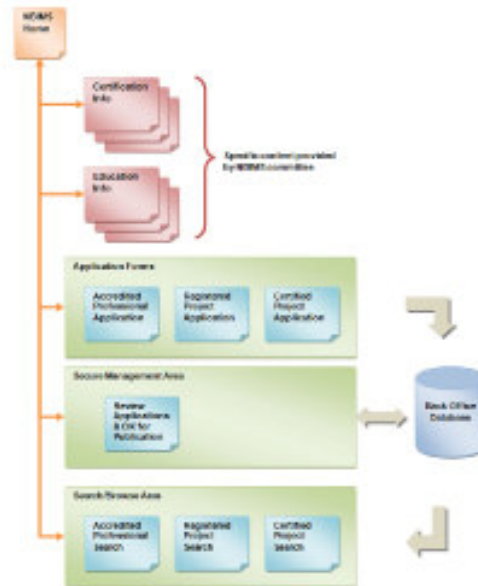


Figure 4.2-8 Proposed Web-Based Application for Certifying BIMs and Accrediting BIM Professionals (Graphic created and provided by Donald F. Sanborn, Unique Solutions, Inc)

The following steps are required to take the CMM to the next level.

- Research is required to evaluate the current level of capability of BIMs in use in the industry today and to ensure that the rankings proposed herein are valid. There is concern that we may have set the bar too high and that most current BIMs will not be certified.
- This section has been initially coordinated with the minimum BIM section³⁴ to ensure that the certified level is in fact what is being described in that section. The concern here is that there are many so-called BIMs in existence that are not truly BIMs, since they are actually only intelligent drawings, visualization tools, or production aides. In a more positive light, the current Capability Maturity Model gives the AECO community a spectrum of tangible capabilities where they can determine their current maturity and use higher levels on the spectrum as developmental goals. Future work will be done to improve the Maturity Model as it needs to be bettered to mirror the burgeoning BIM community.
- The governing body of the NBIMS team will need to certify BIMs and testing processes in order to build a database of best practices and isolate areas of opportunity for improvements in the BIM community. It also needs to provide a means and motivation for users to create reliable information that is stored in open and interoperable formats.

NOTE: The Capability Maturity Model workbook may be downloaded at <http://www.facilityinformationcouncil.org/bim/i-CMM>.

³⁴ See NBIMS Section 4.2.